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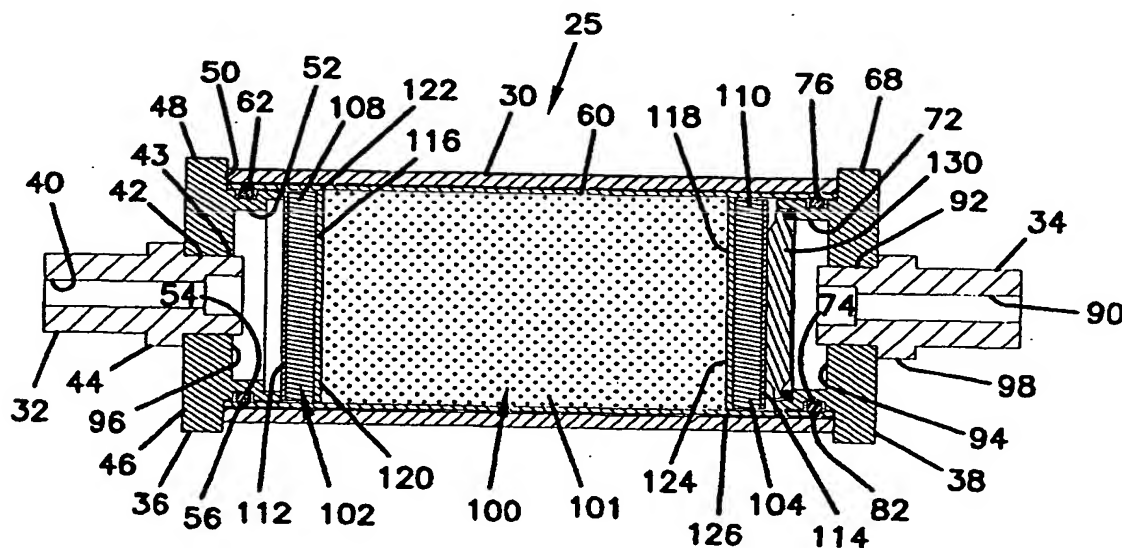
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(54) Title: **GAS CHEMICAL FILTER HAVING COMPRESSION MECHANISM; AND METHODS**

(57) Abstract

A filter assembly includes a construction including a media pack within the construction. In certain arrangements, a compression system exerts force to the media pack both upstream of the media pack and downstream of the media pack. Preferably, the compression system includes a compression pad or a spring both upstream and downstream of the media pack. In preferred systems, the filter assembly is used to clean a high purity gas in order to remove gaseous contaminants therefrom. One example application is in cleaning a gas that is propelled against a lens in optical lithography.

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GAS CHEMICAL FILTER HAVING COMPRESSION MECHANISM; AND METHODS

Field of the Invention

5 This disclosure relates generally to filters and systems using filters. More specifically, this disclosure describes a filter assembly for removing gaseous contaminants from a high purity gas.

Background

10 In the semiconductor industry, semiconductors are fabricated using a combination of lenses and other optical equipment. In many instances, it can be important to keep the lenses and optical equipment clear in order to achieve a quality image.

Summary of the Disclosure

15 This disclosure is directed to a filter assembly. The filter assembly may include a tubular construction having an inlet passage and an outlet passage, a media pack within the tubular construction for removing contaminants from air flowing therethrough, and a compression system for exerting force on the media pack. Preferably, the compression system exerts force both upstream of the media pack and downstream of the media pack.

20 In certain systems, the compression system includes first and second compression members oriented upstream and downstream, respectively, of the media pack.

25 Another aspect of the disclosure concerns a system for removing gaseous contaminants from a high purity gas. One such system may include a supply of high purity gas and a filter construction for removing contaminants from the high purity gas. The filter construction preferably includes a housing, a region of media, such as particulate media, for example, beaded or granular, packed within the housing, a first compression member within the housing exerting compression force on the region of the media upstream of the region, and a second compression member within the housing exerting compression force on the region of media
30 downstream of the region.

Methods for removing gaseous contaminants from a high purity gas are disclosed herein. In one method, there is a step of directing a high purity gas into a filter construction having a region of particulate media, wherein the region of particulate media is compressed both upstream of the region and downstream of the region. Preferably, there is a step of directing the high purity gas through the region of media to at least partially remove gaseous contaminants therefrom. In preferred methods, after the step of directing the high purity gas through the region of media, there is a step of directing the high purity gas out of the filter construction.

Brief Description of the Drawings

FIG. 1 is a schematic depiction of a system for removing gaseous contaminants from a high purity gas using a filter assembly.

FIG. 2 is a side elevational view of one embodiment of the filter assembly depicted in FIG. 1.

FIG. 3 is a cross-sectional view of the filter assembly shown in FIG. 2 taken along the line 3-3.

FIG. 4 is an end view of the filter assembly depicted in FIG. 2.

FIG. 5 is a cross-sectional view of another embodiment of a filter assembly, analogous to the view depicted in FIG. 3.

Detailed Description

A. Some problems with existing systems.

When fabricating semiconductors, a process called optical lithography is used. In this process, a photosensitive layer called photoresist is first spread on a wafer. Light is shined through a photomask to expose the resist in the regions of the wafer where some of the metal resistor layer must be removed. In these exposed regions, a photochemical reaction occurs in the resist that causes it to be easily dissolved in a developer solution. After the develop step, the photoresist remains only in the areas where a resistor is desired. The wafer is then immersed in an acid that etches the exposed metal layer but does not significantly attack the resist. When the etch is complete, the wafers are removed from the acid bath, rinsed, and the photoresist is removed by chemical or plasma techniques.

During this exposure process, the photoresist gives off gasses, for example, acid gasses, during exposure. These gasses can deposit on or dissolve

parts of the lens. To address this problem, in certain systems, a high purity gas, such as compressed nitrogen, is constantly directed in a jet at the imaging lens. This jet of high purity gas prevents the acid gases from the photoresist from attacking the lens.

If the compressed gas used to clean off the imaging lens is not
5 sufficiently pure, residual hydrocarbons, such as hexane, dodecane, and toluene, for example, contained in the gas can collect on the lens and leave a film. The film over the lens negatively affects the imaging properties of the system. In certain instances, it has been found desirable to use a filter in the compressed nitrogen line to remove residual hydrocarbons. Improvements in filtering in these types of systems are
10 desirable in order to effectively remove the residual hydrocarbons.

B. Figs. 1-5

Attention is directed to FIG. 1. In FIG. 1, portions of an optical lithography process are shown schematically at 10. The optical lithography process includes a lens 12 and a wafer or substrate 14. Substrate 14 will include a
15 photoresist spread upon it. Light shines through the lens 12 and onto the substrate 14. As the photochemical reaction occurs on the substrate 14, acids are released into the atmosphere. These acids are prevented from attacking the lens 12 by a jet 16 of a high purity gas, such as nitrogen. A supply of the nitrogen is shown in the form of a tank at 18. The nitrogen gas is compressed and propelled through a conduit 20. In
20 order to remove residual hydrocarbons from the nitrogen gas, the gas is passed through a gas cleaner or filter system shown generally at 25.

In typical operations, the nitrogen gas is under a pressure of between 90-110 psi and passes through the filter construction 25 at a rate of between 30 l/min and 200 l/min.

25 Attention is directed to FIG. 2. FIG. 2 shows the filter system 25 in side elevation. In general, the filter system 25 is constructed and arranged to allow the passage of a gas therethrough, in line, regardless of the orientation of the filter system 25. In the embodiment illustrated in FIG. 2, the filter system 25 includes a filter housing 30, an inlet construction 32, and an outlet construction 34. As can be
30 seen in FIG. 2, in the embodiment shown, the inlet construction 32 and the outlet construction 34 are on opposite ends of the housing 30. This allows for the air to flow in line or straight through. Also shown in FIG. 2 is a first end cap 36 oriented at the inlet end of the housing 30 and a second end cap 38 oriented at the outlet end of the housing 30.

Attention is directed to FIG. 3. FIG. 3 is a cross-section of the filter system 25 taken along the line 3-3 of FIG. 2. As can be seen in FIG. 3, the inlet construction 32 defines a central aperture 40 to allow the passage of air therethrough. Preferably, the inlet construction is selectively attachable and removable from the first end cap 36. For example, the inlet construction 32 may include a threaded shank section 42 for threadably and operably connecting to the end cap 36. The inlet construction 32 includes a shoulder flange 44 that abuts against an outer end surface 46 of the first end cap 36.

In the preferred embodiment shown, the first end cap 36 includes a shoulder or flange 48 that is for engaging or abutting an end 50 of the wall of the housing 30. As can be seen in FIG. 4, the flange 48 of the first end cap 36 is preferably noncircular, in this case, rectangular or square. In the preferred embodiment, the housing 30 is also noncircular, and specifically, rectangular or square.

Referring again to FIG. 3, the first end cap 36 includes a wall 52 projecting from the flange 48. Preferably, the wall 52 is continuous and surrounds or circumscribes the central aperture 43 of the end cap 36. As can be seen in FIG. 3, the wall 52 has a diameter less than the diameter of the flange 48. In this matter, the wall 52 is permitted to be received within the housing 30.

The first end cap 36 is constructed and arranged to hold a sealing member for forming a seal between the end cap 36 and a tubular construction in the housing 30. In particular, the wall 52 defines a gasket seat 54. Preferably, the gasket seat 54 is a region of reduced diameter in the wall 52 to form a cradle for holding a gasket or O-ring 56. The O-ring 56 compresses against an inner tubular construction 60 to form a seal 62 therebetween.

Still referring to FIG. 3, the tubular construction 60 preferably is a hollow tube having a continuous wall for holding and containing the inner filter components. The tubular construction 60 preferably fits snugly against the wall of the housing 30. Preferably, the tubular construction 60 engages and extends between first end cap 36 and second end cap 38.

The second end cap 38 is preferably constructed identical to the first end cap 36. As such, it includes a flange 68, a wall 72, and a gasket seat 74. An O-ring 76 cooperates with the tubular construction 60 to form a seal 82 therebetween.

The outlet construction 34 is preferably identical to the inlet construction 32. As such, the outlet construction 34 has a central aperture 90, a threaded shank section 92, and a shoulder flange 94.

As can be seen in FIG. 3, the inlet aperture 40 is in gas flow communication with an inlet passage 96 within the tubular construction 60 and within the wall 52 of the first end cap 36. Analogously, there is an outlet passage 98 within the tubular construction 60 and contained within the wall 72 of the second end cap 38. The outlet passage 98 is in gas flow or airflow communication with the outlet aperture 90.

In the filter system 25, there is a region of media for removing impurities within gas that passes through. Preferably, the media includes a media pack 100 within the tubular construction 60. The media pack 100 operates to at least partially remove contaminants, such as residual hydrocarbons, from air or gas, such as nitrogen, flowing therethrough. Preferably, the media pack 100 comprises a particulate media 101, such as beaded media or granular media. More preferably, the particulate media comprises a beaded media 101 that is spherically shaped. In particular, one type of beaded media preferred is spherical carbon beads. The spherical carbon beads function to allow the flow of gas therethrough and absorb impurities, such as residual hydrocarbons, from the high purity gas.

Preferably, the filter system 25 includes a compression system for exerting force on the media pack 100. The compression system maintains the media pack 100 to be maintained in a tight, packed condition between the individual beads in order to prevent leaks. The compression system allows the filter system 25 to be used in any orientation, by compressing on the media pack 100 from all directions. By compressing on the media pack 100 from all directions, the media pack 100 is prevented from settling. If the particulate media 101 were allowed to settle, a gas flow path may develop between the inlet construction 32 and outlet construction 34 without having to travel through any of the media 101.

In particular, in preferred systems, the compression system exerts force both upstream of the media pack 100 and downstream of the media pack 100. Also preferred is a compression system that is gas or air permeable. That is, the compression system preferably allows gas or air to freely flow therethrough. The preferred force of the compression system is preferably exerted from both directions and from the surrounding wall of the tubular construction 60 to put constant force on

the particulate media to prevent settling. In certain embodiments, the compression system includes at least a single compression member. In the embodiment illustrated in FIG. 3, the compression system includes first and second compression members 102, 104. The first compression member 102 is located upstream of the media pack 100. The second compression member 104 is located downstream of the media pack 100. While a variety of implementations are envisioned, in the embodiment illustrated in FIG. 3, the first compression member 102 comprises a compressible pad 108 squeezed between the first end cap 36 and the media pack 100. Preferably, the compressible pad 108 is gas or air permeable. More preferably, the compressible pad 108 is a circular open cell polyurethane pad having at least 30 pores per in., and preferably between 40 – 100 pores per in., for example, 50 pores per inch. Compressed within a filter system 25 as shown, the compression pad 108 will exert a force sufficient to compress the media pack 100. For example, certain usable compression pads 108 will exert a force of at least 10 N, and preferably between 10 – 35 N on the media pack 100.

In the preferred embodiment shown in FIG. 3, the second compression member 104 also includes a compression pad 110. The compression pad 110 is preferably identical to the compression pad 108. The compression pad 110 is downstream of the media pack 100 and compressed between the second end cap 38 and the media pack 100.

Also shown in FIG. 3, a porous screen 112 is compressed between the first end cap 36 and the pad 108. Analogously, there is a screen 114 pressed against the compression pad 110. Screens 112, 114 help to support the pads 108, 110. The screens 112, 114 also provide some filtering function by preventing larger particles from passing therethrough. Preferably, the screens 112, 114 comprise a mesh of expanded metal.

Preferably, the filter system 25 also includes first and second regions of media, for example, depth media 116, 118 located upstream and downstream of the media pack 100. In the illustrated embodiment, the first region of depth media 116 is within a media disk 120. Media disk 120 has an outer surrounding housing 122 circumscribing the depth media 116. The depth media 116 assists to keep the particulate media, i.e. beads or grains, in the media pack 100 within the tubular construction 60. That is, the depth media 116 helps to contain or trap or prevent the particulate media 101 from passing therethrough and penetrating into the inlet

passage 96. The depth media 116 is porous enough to permit the flow of gas therethrough without imposing an undue amount of restriction.

The second region of depth media 118 is preferably within a media disk 124 that is constructed analogously to media disk 120. As such, it includes an outer surrounding housing 126. The depth media 118 assists in preventing the particulate media 101 from traveling and embedding into downstream components.

The filter system 25 also preferably includes a system for collecting any particulates before being allowed to pass through the outlet passage 98 and in through the aperture 90. In the embodiment shown in FIG. 3, there is shown a filter disk 130. Preferably, the filter disk 130 operates as a sieve to collect the particles that may have made it through the upstream components of the filter system 25. In certain preferred systems, the filter disk 130 includes a pleated metal screen. The screen will collect particles larger than at least 7 microns. Preferably, there are between 8–14 pleats, each having a pleat depth of preferably between 0.08–0.12 inches.

In reference again to FIG. 4, it can be seen that the end cap 36, and analogously the end cap 38, is releasably attached to the housing 30 through fasteners, such as screws 134.

Turning now to FIG. 5, second embodiment of a filter system is shown generally at 150. The filter system 150 includes parts that are analogous to the filter system 25, with the exception of the compression system. In the embodiment shown in FIG. 5, the compression system includes a first compression member 152 and a second compression member 154. The first compression member 152 preferably is a compression pad 156, analogous to the compression pad 108 and compression pad 110 of FIG. 3.

The second compression member 154 in this embodiment is preferably a spring 158. The spring 158 can be seen in cross-section as a coiled spring that exerts a force sufficient to compress the media pack 160. For example, forces of at least 10 N, preferably about 10–35 N are useful.

The spring 158 is advantageous in the process 10 because it is less prone to outgassing or offgassing. "Offgassing" is the release of gaseous contamination by facilities, equipment, tools, etc. during the semiconductor fabrication process.

In operation, the filter systems described herein operate to remove gaseous contaminants from a high purity gas. By "high purity gas", it is meant, for example, class 5 nitrogen. By "gaseous contaminants", it is meant, for example, residual hydrocarbons. A high purity gas is directed into a filter construction, such as those described herein, having a region of beaded media. The beaded media is compressed both upstream of the region of beaded media and downstream of the region of beaded media. In this way, the filter construction may be used in any orientation, and there is no significant likelihood that the beaded media will settle to allow gas a path to flow without being subject to the beaded media. A high purity gas is directed through the region of beaded media to at least partially remove gaseous contaminants therefrom. After the step of directing the high purity gas through the region of beaded media, the high purity gas is directed out of the filter construction.

In particular, in reference to FIG. 3, a high purity gas such as nitrogen passes through the inlet aperture 40 and into the inlet passage 96. There, it passes through the screen 112, through the compression pad 108, through the depth media 116, and into the media pack 100. The gas flows through the carbon particles of the media pack 100 where it is subject to having hydrocarbons and other contaminants absorbed by the carbon. The purified gas then passes through the second region of depth media 118 that removes any other particles that have made it through. The purified gas then passes through the second compression member 104, and through the screen 114, and through the filter disk 130. The filter disk 130 operates to remove any other particles larger than a certain size, such as 7 microns, from the gas. The purified gas then flows through the outlet passage 98 and out through the outlet aperture 90. From there, it may be sprayed onto a lens 12.

C. Preferred Materials

In this section, example material specifications are provided. Of course, other materials may be used.

Preferably, the beaded media 101 comprises spherical carbon beads. Each of the carbon beads is between 0.5–0.7 mm in diameter. It has a dry apparent bulk density of 0.55–0.61 g/ml when tested per ASTM D2854. The moisture content preferably is 3% maximum by weight when tested per ASTM D2867.

Preferably, each of the compression pads 108, 110, 156 comprise an open cell polyester urethane, fully reticulated, with at least 30 pores per in, preferably 50 pores per in.

The filter disk 130 preferably comprises 0.16 in aluminum binding, having a screen of 325 by 2300 mesh, at least 7 microns, and about 8 microns, absolute. The screen pleat depth is approximately 0.10 in., and the screen material preferably comprises stainless steel 304.

Each of the media disks 120, 124 includes a region of depth media 116, 118, respectively. The depth media preferably comprises a blend of fibers, most preferably 50% polypropylene and 50% modacrylic. This fiber mixture exhibits a permanent electrical potential. The fomblin efficiency preferably is between 76–94% average, tested at 10.5 ft per min airflow, with 0.3–0.4 micron particles. There should be no single value below 71 or above 99. The permeability preferably is between 283–476 ft per min (86–145 meters per min). The thickness at 0.5 psi is preferably 0.035–0.061 in. (0.91–1.55 mm). The basis weight preferably is between 48–75 lbs/3000 ft sq (78–122 g/m²). Preferably, each of the screens 112, 114 comprise expanded metal having a strand thickness of 0.028 in. (0.71mm), and a percent open area of about 72%.

Preferably, the housing 30 is constructed of aluminum. Preferably, the tubular construction 60 is constructed of 304 stainless tubing, seamless, cold finished, annealed, and pickled. The material has a 20 gauge wall (0.035 in.).

Preferably, the O-rings 56, 76 comprise a synthetic rubber such as vinylidene fluoride – hexafluoropropylene, having a hardness of between 60 and 75 Shore A, for example VITON®, a registered trademark of DuPont, or FLUOREL®, a registered trademark of 3M. These materials are advantageous and preferred because they have low offgas potential.

Preferably, the first and second opposite end caps 36, 38 comprise stainless steel.

30 D. Example Preferred Constructions

It will be understood that wide variety of specific configurations and applications are feasible, using techniques and principles described herein. In this section, a particular filter assembly will be described.

The overall length of the filter system 25 between the tip of inlet 32 and the tip of outlet 34 is at least 2.79 in. (7.09 cm), for example 2.79–13.04 in. (7.09–33.12 cm), preferably 6.52 in. (16.6 cm).

5 The length of the filter system 25 between the end of end cap 36 and the end of end cap 38 is at least 2.0 in. (5.08 cm), for example 2.0–12.5 in. (5.08–31.75 cm), preferably 4.64 in. (about 11.8 cm).

Each of the end caps 36 and 38 have dimensions of between 1 by 1 in. (2.54 by 2.54 cm) to 6 by 6 in. (15.24 by 15.24 cm.) preferably 2 by 2 in. (about 5.1 by 5.1 cm).

10 Each of the compression pads 108, 110, 156 has a diameter of at least 0.5 in. (1.27 cm), for example 0.5–5.5 in. (1.27–13.97 cm.), preferably 1.52 in. (about 3.86 cm). Each of the compression pads has a thickness of at least 0.25 in. (0.64 cm), for example 0.25–0.5 in. (0.64–1.27 cm), preferably 0.375 in. (about 0.95 cm).

15 The filter disk 130 has an outer diameter of at least 0.8 in. (2.03 cm), for example 0.8–5.25 in. (2.03–13.34 cm), preferably 1.365 in. (about 3.47 cm). The thickness of the filter disk is at least 0.05 in., for example 0.052–0.25 in., preferably 0.163 in. (about 0.414 cm).

20 Each of the media disks 120, 124 has a diameter of at least about 0.5 in. (1.27 cm), for example 0.5–5.5 in. (1.27–13.97 cm), preferably 1.555 in. (about 3.95 cm).

Each of the screens 112, 114 has a diameter of at least 0.5 in. (1.27 cm), for example 0.5–5.5 in. (1.27–13.97 cm), preferably 1.52 in. (about 3.86 cm).

25 The tubular construction 60 has a length at least 1.2 in. (3.05 cm), for example 1.2–8.2 in. (3.05–20.83 cm), preferably 4.10 in. (about 10.4 cm). It has an inner diameter of at least 0.5 in. (1.27 cm), for example 0.5–5.5 in. (1.27–13.97 cm), preferably 1.555 in. (about 3.95 cm). It has an outer diameter of at least 0.55 in. (1.40 cm), for example 0.55–5.65 in. (1.40–14.35 cm), preferably 1.625 in. (about 4.13 cm).

30 Each of the O-rings 56, 76 has an inner diameter of at least 0.6 in. (1.52 cm), for example 0.6–5.25 in. (1.52–13.34 cm), preferably 1.239 in. (about 3.15 cm). Each of the O-rings 56, 76 has an outer diameter of 0.67–5.32 in. (1.70–13.51 cm), preferably 1.379 in. (about 3.50 cm).

Each of the inlets and outlets 32, 34 has a length of at least 0.25 in. (0.64 cm), for example 0.25–3.0 in. (0.64–7.62 cm), preferably 1.33 in. (about 3.38 cm). Each has an aperture diameter of at least 0.08 in. (0.20 cm), for example 0.08–0.5 (0.20–1.27 cm), preferably 0.19 in. (about 0.48 cm.).

CLAIMS:

1. A filter assembly (25) comprising a construction defining an inlet passage (32) and an outlet passage (34); a media pack (100) within said construction for at least partially removing contaminants from gas flowing therethrough; the filter assembly being characterized by:
 - (a) a compression system (102, 104) for exerting force to said media pack;
 - (i) said compression system exerting force at a point at least either upstream of said media pack and downstream of said media pack; and
 - (ii) said compression system comprising a gas permeable construction to permit gas to flow therethrough.
2. A filter assembly according to claim 1 wherein:
 - (a) said media pack comprises beaded media or granular media; and
 - (b) said construction comprises a tubular construction (60).
3. A filter assembly according to claim 2 wherein:
 - (a) said compression system includes first and second compression members;
 - (i) said first compression member (102) being oriented within said tubular construction, upstream of said media pack; and
 - (ii) said second compression member (104) being oriented within said tubular construction downstream of said media pack.
4. A filter assembly according to claim 3 including:
 - (a) a first end cap (36) closing a first end of said tubular construction;
 - (i) said first end cap defining an aperture (43) therethrough in airflow communication with said inlet passage;
 - (b) a second end cap (38) closing a second end of said tubular construction;
 - (ii) said second end cap defining an aperture therethrough in airflow communication with said outlet passage.

5. A filter assembly according to claim 4 wherein:
 - (a) said first compression member comprises a compressible pad (108) squeezed between said first end cap and said media pack.
6. A filter assembly according to claim 5 wherein:
 - (a) said second compression member comprises a compressible pad (110) squeezed between said second end cap and said media pack.
7. A filter assembly according to claim 5 wherein:
 - (a) said second compression member comprises a spring (158).
8. A filter assembly according to claim 5 further including:
 - (a) a first region of depth media (116) between said first compression member and said media pack; and
 - (b) a second region of depth media (118) between said media pack and said second compression member.
9. A filter assembly according to claim 8 further including:
 - (a) a filter disk (130) downstream of said media pack.
10. A filter assembly according to claim 9 wherein:
 - (a) said filter disk is compressed between said second end cap and said second compression member.
11. A filter assembly according to claim 10 further including:
 - (a) a housing (30); said tubular construction being oriented within said housing.
12. A filter assembly according to claim 11 wherein:
 - (a) said first and second regions of depth media comprise fibrous, polyester depth media.
13. A filter assembly according to claim 12 further including:

- (a) a first seal member (56) for forming a seal (62) between said first end cap and said tubular construction; and
 - (b) a second seal member (76) for forming a seal (82) between said second end cap and said tubular construction.
- 14. A system (10) for removing gaseous contaminants from a gas; the system comprising:
 - (a) a supply of gas (18); and
 - (b) a filter assembly according to any one of claims 1–13; the filter assembly being constructed and arranged to remove contaminants from the gas.
- 15. A system according to claim 14 wherein:
 - (a) said supply of gas comprises nitrogen.
- 16. A method for removing gaseous contaminants from a high purity gas; the method including:
 - (a) directing a gas into a filter assembly according to claim 1; the filter assembly having a region of beaded or granular media; the region of beaded or granular media being compressed both upstream of the region and downstream of the region;
 - (b) directing the gas through the region to at least partially remove gaseous contaminants therefrom; and
 - (c) after said step of directing the gas through the region, directing the gas out of the filter construction.

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FIG. 1

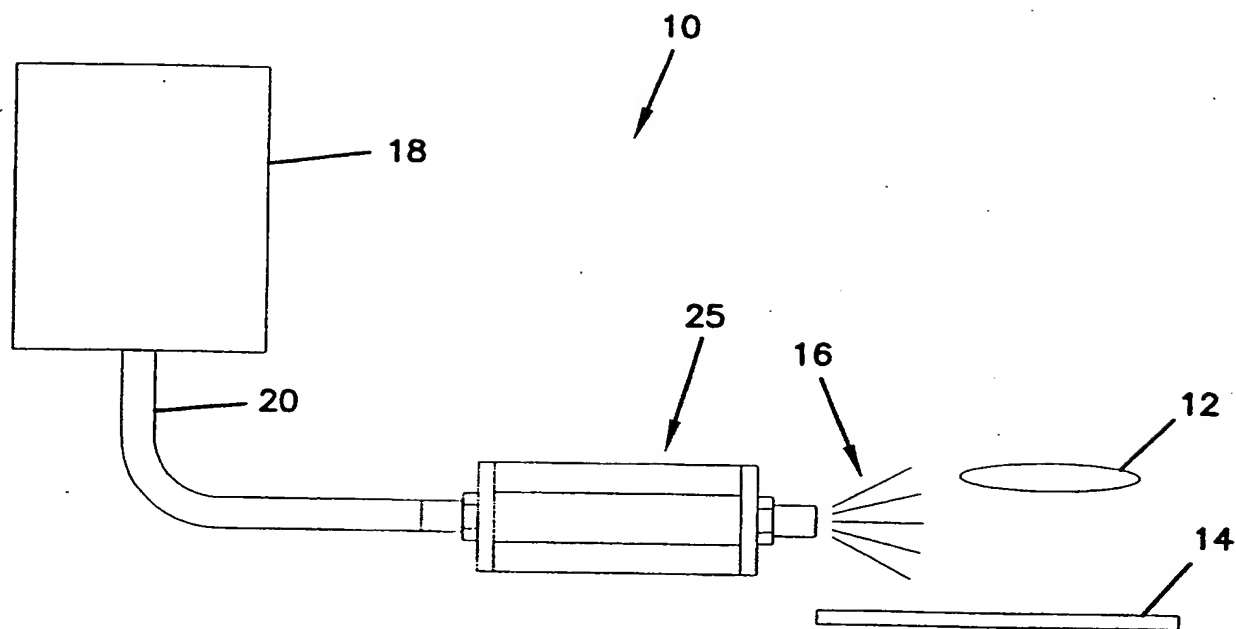
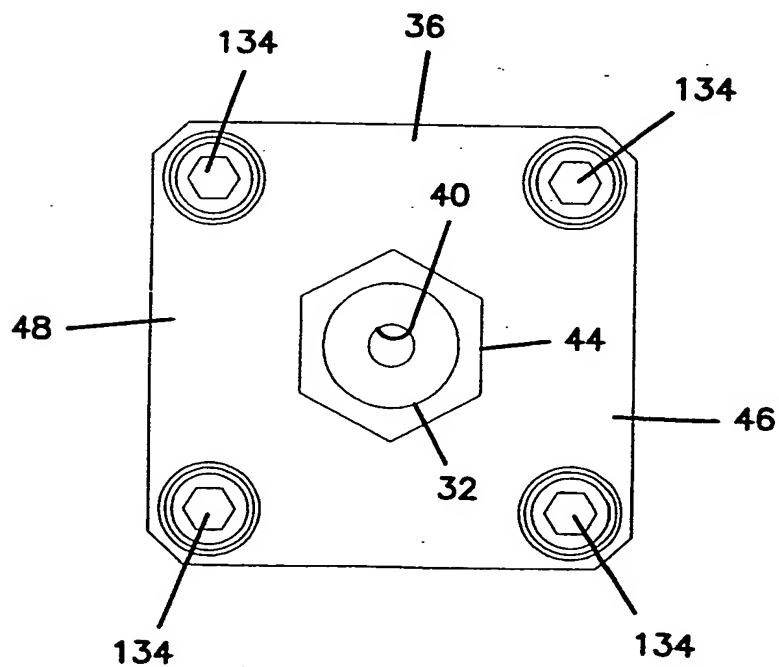


FIG. 4



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FIG. 2

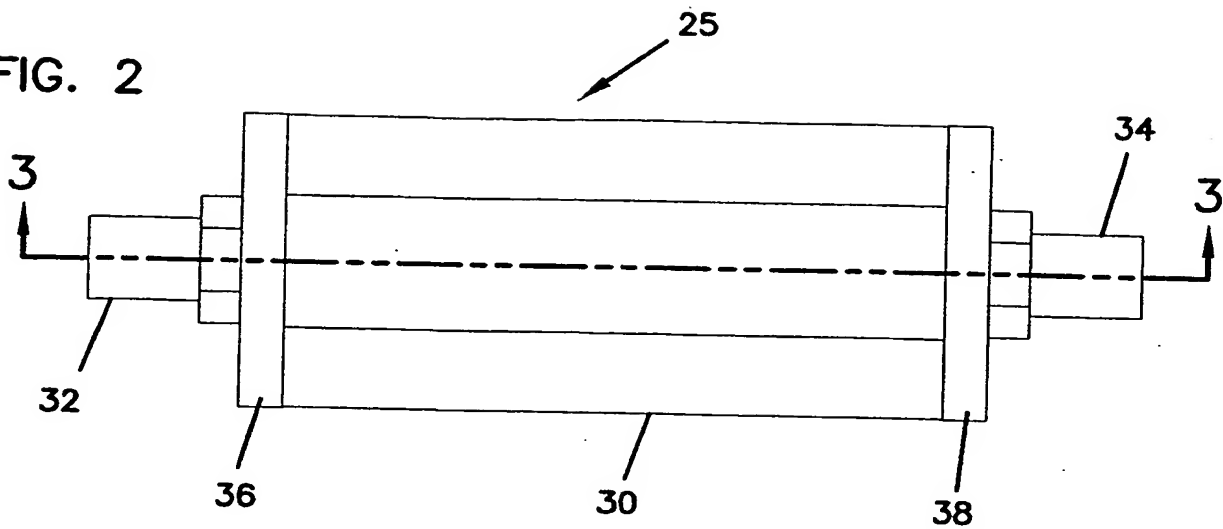


FIG. 3

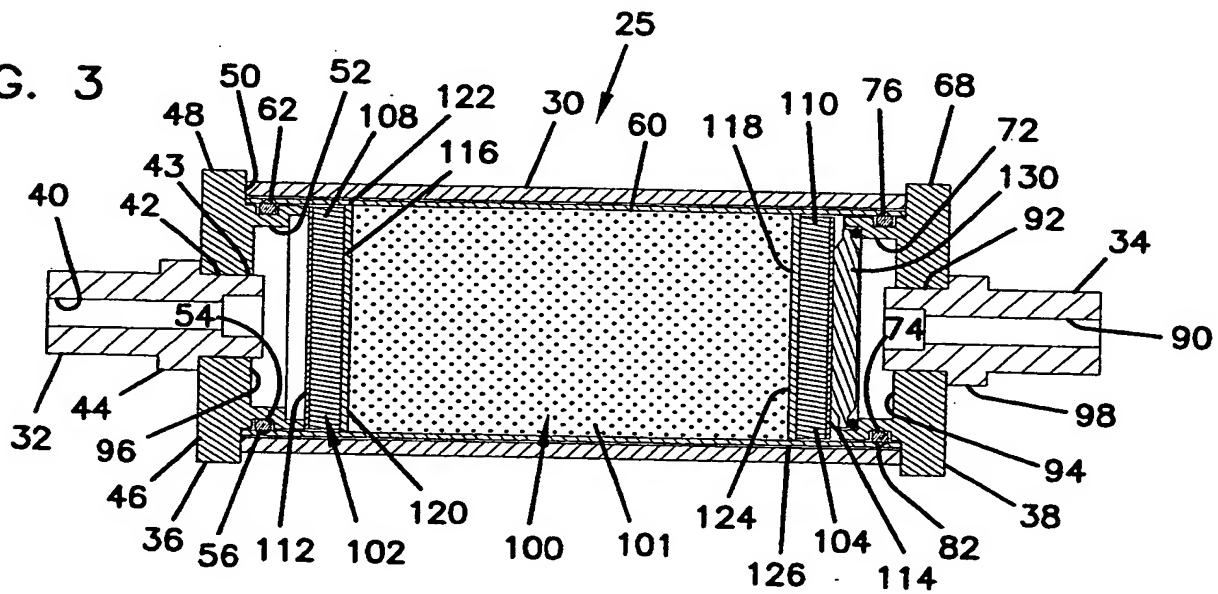
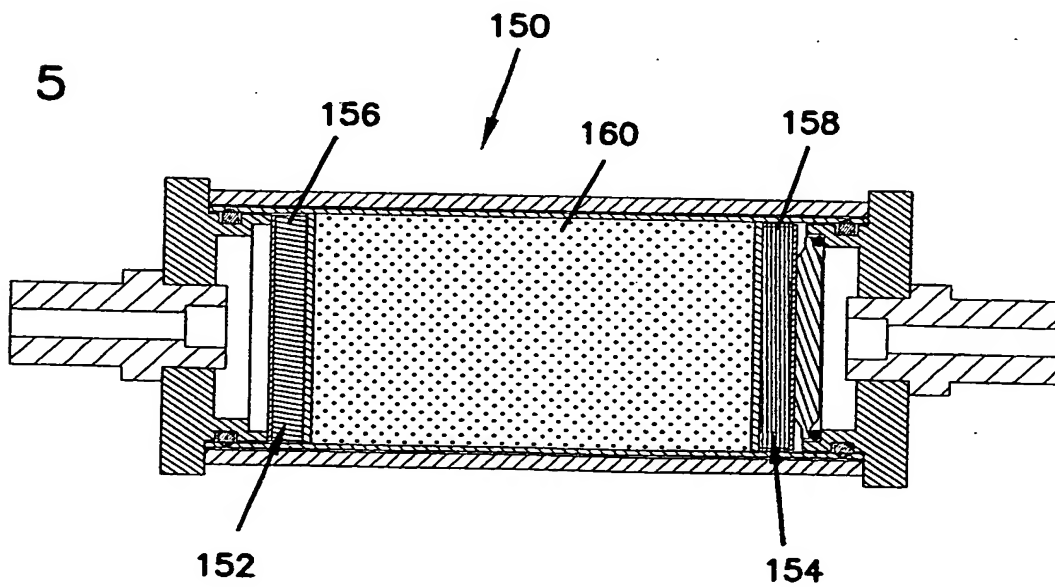


FIG. 5



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INTERNATIONAL SEARCH REPORT

Inter: onal Application No

PCT/US 99/25152

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D53/04 B01D46/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B01D 601N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 39 24 341 A (ERNEST DE RUITER ET AL.) 31 January 1991 (1991-01-31) the whole document	1-3,5,6, 8,14-16
A	US 4 612 026 A (F.J.POLLARA ET AL.) 16 September 1986 (1986-09-16) claim 1; figure 1	1,7
A	US 4 026 685 A (A.R.GRIX) 31 May 1977 (1977-05-31) claim 1; figure 3	1,4
A	DE 23 04 990 A (PLASTIC ENGINEERS LTD) 16 August 1973 (1973-08-16) claims 1,5; figure 1	1



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

*** Special categories of cited documents:****"A"** document defining the general state of the art which is not considered to be of particular relevance**"E"** earlier document but published on or after the international filing date**"L"** document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)**"O"** document referring to an oral disclosure, use, exhibition or other means**"P"** document published prior to the international filing date but later than the priority date claimed**"T"** later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention**"X"** document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone**"Y"** document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.**"Z"** document member of the same patent family

Date of the actual completion of the international search

9 March 2000

Date of mailing of the international search report

17/03/2000

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Authorized officer

Bertram, H

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/25152

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